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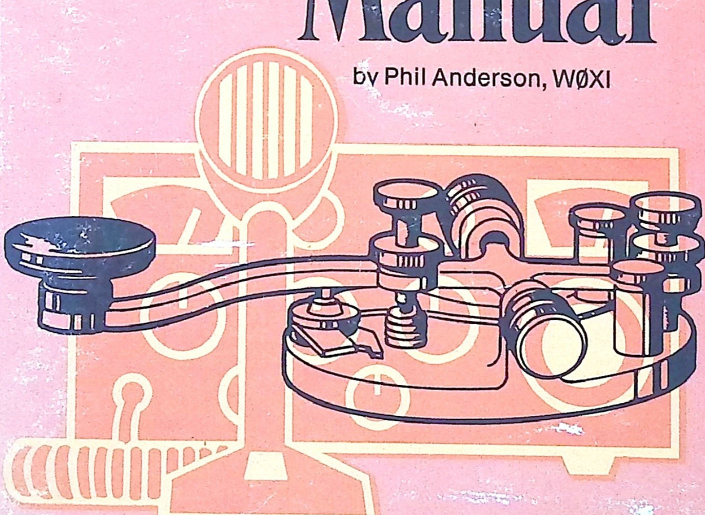
Novice Class
Amateur Radio License Manual

by Phil Anderson, W0XI



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Novice Class
Amateur Radio
License Manual

by Phil Anderson, W0XI

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Preface

The single purpose of this manual is to help you to obtain your Novice Amateur Radio License. There are four basic things that you will need: (1) a place to take the examination, (2) an understanding of the FCC (Federal Communications Commission) rules governing amateur radio, (3) the ability to receive and send Morse code at five words per minute, and (4) an understanding of some very elementary electronic laws. This manual will provide you with the necessary information in all four of these areas.

There are various ways to prepare yourself for the exam: through self-study, studying with an amateur radio friend (ham), or by attending a class sponsored by a local amateur radio club. If you choose self-study, then you will need to obtain some cassette tapes or a shortwave receiver to listen to Morse code. Chapters 2 and 3 outline the procedure for learning to receive and send code. Learning with a class can be fun, too. Sometimes you can find a class near you by contacting the local amateur club or your area high school. Working with an amateur radio operator directly can be an excellent way to master the material for the exam quickly. If you do not know an amateur now, the information in Chapter 1 will help you to locate those in your area. The vast majority of ham operators are very friendly and are happy to help someone who is interested in their hobby.

Examinations are given in practically all major cities at FCC offices or the Novice exam can be taken locally if it is administered by a volunteer amateur examiner.

The rules governing amateur radio are outlined in Part 97 of the FCC rules. Chapter 6 lists those rules that are applicable to the Novice licensee. You will want to study these regulations closely because it is likely that questions about them will appear on the exam.

Learning Morse code can be fun if you approach it right. Do not, however, expect to learn to receive code in one or two sittings. It just takes a little time and best results will be obtained by studying a bit at a time every day or so for a couple of weeks. Twenty or thirty minutes a day should do it.

There are really very few electronic laws that you have to learn. You do not have to be a design engineer or technician to pass the exam. With some serious study you will grasp the basic ideas such as: frequency, wavelength, power output, and Ohm's law. Chapter 5 presents the basic electronic concepts. If you are already an electronic expert, that is fine.

The last chapter contains some sample exam questions and answers. If you study all the chapters and can answer the questions in each chapter, then the exam should go smoothly. The Novice exam is multiple choice and a passing grade can be obtained if you get 74% or better of the answers correct.

Good luck and welcome to amateur radio.

PHIL ANDERSON, W0XI

To Mom and Dad for their support and encouragement.

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chapter 1

Requirements and Information Sources

To operate an amateur radio station you need an amateur radio operator's license plus a station license. Both licenses are issued as one on a computer form once you have passed the required examination.

There are five classes of amateur license: Novice, Technician, General, Advanced, and Extra Class. The Novice class is the initial license and allows for operation on a portion of four of the amateur bands. This book is intended to prepare the prospective ham—the commonly used term for an amateur radio operator—for the Novice Exam only. If you are interested in the Technician class ticket or above you will need additional study material.

REQUIREMENTS FOR NOVICE CLASS LICENSE

If you take the Novice exam at an approved FCC location, you will have to pass a code test and a written exam. The code test consists of receiving code at five words per minute and answering questions on the content of the message sent to you. The written exam will consist of multiple-choice questions on FCC regulations, radio theory, and station operation procedures.

You can take the written exam for the Novice by mail if it is administered by an amateur holding a General-class or higher grade license. However, as present rules stand, you must take the code test in sending and receiving from the volunteer examiner. Then, once you have passed the code test, the examiner can write for the Novice class written exam. Be patient; it may take a little time for the exam to arrive. Applications have increased considerably in the last few years.

FINDING LOCAL AMATEURS

It should be easy to find the radio amateurs in your area. Ask people you know about amateur radio; chances are, somebody can introduce you to a ham operator. There is one amateur for every four hundred people in the United States. Also, check with the local Civil Defense office. Most radio clubs help with emergency communications and the director will probably have several names for you. Another source could be your local high school adult education office or junior college. Many adult education programs offer courses for exam preparation.

If you want to make an adventure of it, watch for radio towers in your community. Sooner or later you will locate an obvious ham radio operator like the one in Fig. 1-1 by the "antenna farm" in the ham's back yard.

MAGAZINES

You can find a lot of information on ham radio by reading one or several of the ham hobby magazines. Names and addresses of some of them are listed in Table 1-1. These magazines are really the only readily available source of information for current events in the hobby, such as ham-fests. They also provide information on available equipment, additional publications, vendors, club news, contests, news from Washington on ham radio, a listing of some retail outlets, and, in some cases, exam schedules. Every aspect of the hobby is presented or featured if you scan enough issues.

Once you have studied the material presented in this book, the magazines will help to provide additional study material

Fig. 1-1. The enjoyment of amateur radio.

Table 1-1. Amateur Radio Magazines

Title	Address
QST(ARRL)	225 Main Street, Newington, CT 06111
Ham Radio	Greenville, NH 03048
Ham Radio Horizons	Greenville, NH 03048
CQ	14 Vandeventer Avenue Port Washington, L.I., NY 11050
73	Peterborough, NH 03458
Worldradio	2120 28th Street Sacramento, CA 95818

for the exam. Most of them feature a Novice or beginner section and review basic radio theory and operational concepts. In addition, many suggestions about equipment for beginners are presented and new products are reviewed. Also, if you are do-it-yourself oriented, construction projects are numerous. It is highly recommended that you review some of these publications.

The cheapest way to check out which magazine you like best is to borrow and read several issues from a ham friend or from the local library. If this is not convenient, try purchasing a few issues from a local newsstand, retail bookstore, or write one of the magazines for a trial subscription.

EXAM LOCATIONS

Although not all cities have FCC exam centers for amateur licensing, most large cities do. For example, anybody living in Kansas or Missouri can take an exam in Kansas City at the Federal Building each Tuesday morning. You can locate the nearest FCC exam centers by contacting the FCC. Most FCC centers have a recorded message dictating time and place for the exams. Use the white pages of the nearest large city phone book and you will find the FCC listed under U.S. Government Offices. Time and place for exams will sometimes vary among outlying exam centers.

chapter 2

Learning Morse Code

The key to obtaining your Novice license is to be able to receive International Morse Code. It is not hard to learn to receive code but you must expect to spend some time in doing so. In addition, the more proficient you become with the code, the more fun it is. In effect, the code becomes another language and knowledge of it can be very enjoyable and satisfying.

Learning to receive code generally takes more time than learning to send it. So concentrate on receiving code in the process of working toward your goal of the Novice license. Also, as you may recall from the introduction, sending the code is not required if you take the exam at an FCC location.

What will you need in the way of supplies and equipment? You will need some way to produce code that you can hear and write down on paper. This can be in the form of code placed on cassette tape or regular audio tape, code received directly from a radio receiver, or code sent by a friend on a key and audio oscillator or by saying the code aloud. Now, let's examine how Morse code is defined.

THE STRUCTURE OF MORSE CODE

Code is made up of short and long tones, called elements, properly spaced in time. Short tones are called *dits* and long tones are called *dahs*. Messages are coded by the following rules:

1. *Dits* are one unit of time.
2. *Dahs* are three units of time.
3. *Dits* and *Dahs* are separated by one unit of time when coding letters.
4. Coded letters are separated by three units of time when coding a word.
5. Seven units of time are used to space between coded words.

The following examples show how the rules apply.

Example 1. Code for the letter A is *dit dah.* Fig. 2-1 shows this code diagrammed in time. *Dits* are pronounced like combining D and it—Dit. Sometimes when dits are combined with dahs a short form is used called a Di. Simply leave off the t. So the code for the letter A is pronounced *dit dah* or *di dah.* The di should sound short and the dah should sound long. Do not leave any space between the dit and dah but just say di-dah as one word.

Example 2. Code for the letter R is *dit dah dit* or in short form *di dah dit.* To get the rhythm of it, hold the dah out a bit—say di-daaaah-dit. The code is diagrammed in time in Fig. 2-1.

Example 3. Code for the letter T is just *dah.*

Example 4. Using the above rules, the time duration between two characters of a single word is the duration of a dah. For example, the word ART, shown diagrammed in time in Fig. 2-1, is coded dit dah–dit dah dit–dah. Just to make sure we are together, let's send the word ART in code by saying it aloud. Di-dah—pause—di-dah-dit—pause—dah.

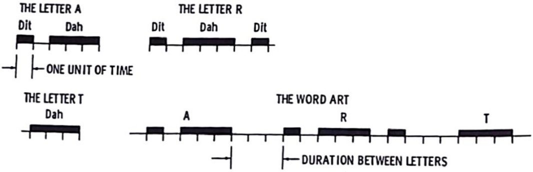


Fig. 2-1. Dits and Dahs make letter codes.

Now try the word RAT. It's coded di dah dit–di dah–dah or R—pause—A—pause—T.

In summary, letters, numbers, and punctuation can be coded by using combinations of dits and dahs. These dits and dahs are tones which each have a defined duration of time. In addition, these coded letters can be combined with proper spacing to make words and sentences.

DEFINITION OF CODE SPEED— WORDS PER MINUTE

FCC rules say that you must pass a code receiving test at a *code speed* or rate of five words per minute. So what or how many are five words per minute?

Code speed is rated at so many words sent or received per minute where a word is considered to be five characters in length. So, if twenty-five characters are sent in one minute, including spaces as characters, the rate is twenty-five characters per minute or 25/5 words per minute. In general, code speed is the number of characters received divided by five and then divided by the time in minutes to receive it. For example, if the following sentence were sent in two and one-half minutes—

> WE SUGGEST YOU LEARN EACH CODE GROUP LISTED BEFORE PROCEEDING ON TO THE NEXT GROUP.

—the code speed would be WPM (words per minute) = 84 characters divided by 5 and then divided by 2.5, or

$$\text{WPM} = \frac{84 \div 5}{2.5} = 6.7$$

Incidentally, the rules count numbers and punctuation as two characters. This occurs because the length of the codes for these symbols is so long.

Now, let's see how you should learn to receive the code so that your receiving speed increases easily.

LEARNING THE MORSE CODE

Many amateurs have learned the code over the years. Experience shows that it is best to learn a little at a time and to space your study sessions out on a regular time schedule. Like most learning activities, practice is essential to learn to receive code well. Experience has also shown that it does not matter how smart you are. It is just going to take a little time to learn the code well. Morse code is the great equalizer because you cannot force it into your head—just take it in easy.

Some basic rules can make it both easy and fun:

1. Be patient.
2. Memorize a few letters at a time.
3. Listen to the *sound* of each letter rather than the sequence of dits and dahs. This is very important for increasing your speed later.
4. Try listening to code before sending it to get the correct *sound* and rhythm.
5. Practice on a regular basis.

Chart 2-1 divides the letters of the alphabet, numbers, and punctuation into six groups. Learn the character codes listed one group at a time. Memorize the sound of the letters and not the sequence of dits and dahs. Sound out the letters to yourself. If you try to memorize the sequence of elements, you first have to convert the sound to the sequence and then the sequence to the letter. This takes too long. Take your time and do not spend too much time at each sitting. Twenty to thirty minutes a session is sufficient practice time at first.

You might wonder at this point how you are going to do this by yourself. You can begin by memorizing each group of codes and sounding out the code for each of the letters. The flash-card method outlined next is to help you get started. However, it is best to have a friend send you the codes for the letters on a code oscillator or, cheaper yet, to sound them out to you. This way you actually practice receiving code. Also, many of the cassette tape vendors present the code in small groups of letters at the beginning of their Novice tapes.

USING FLASH CARDS TO MEMORIZE THE CODE

A good way to learn to listen and hear the sound of Morse code characters is to make and practice with flash cards (Fig. 2-2). The idea is to use four or five cards at a time, each

Chart 2-1. The Morse Code by Character Groups

Group I	E	dit					
	T	dah					
	A	dit	dah				
	R	dit	dah	dit			
Group II	S	dit	dit	dit			
	L	dit	dah	dit	dit		
	U	dit	dit	dah			
	Q	dah	dah	dit	dah		
	J	dit	dah	dah	dah		
Group III	H	dit	dit	dit	dit		
	O	dah	dah	dah			
	N	dah	dit				
	C	dah	dit	dah	dit		
	V	dit	dit	dit	dah		
Group IV	I	dit	dit				
	B	dah	dit	dit	dit		
	Y	dah	dit	dah	dah		
	P	dit	dah	dah	dit		
Group V	W	dit	dah	dah			
	K	dah	dit	dah			
	Z	dah	dah	dit	dit		
	M	dah	dah				
	D	dah	dit	dit			
	X	dah	dit	dit	dah		
	F	dit	dit	dah	dit		
	G	dah	dah	dit			
Group VI	1	dit	dah	dah	dah	dah	
	2	dit	dit	dah	dah	dah	
	3	dit	dit	dit	dah	dah	
	4	dit	dit	dit	dit	dah	
	5	dit	dit	dit	dit	dit	
	6	dah	dit	dit	dit	dit	
	7	dah	dah	dit	dit	dit	
	8	dah	dah	dah	dit	dit	
	9	dah	dah	dah	dah	dit	
	0	dah	dah	dah	dah	dah	
	,	dah	dah	dit	dit	dah	dah
	?	dit	dit	dah	dah	dit	dit
	-	dah	dit	dit	dit	dah	
	.	dit	dah	dit	dah	dit	dah

of which has the code on one side and the corresponding letter for that code on the other. To practice receiving, look at the code and sound it out and then say what letter corre-

Fig. 2-2. Flash cards can help you memorize the code.

sponds to it. For example, code for the letter C is dah-di-dah-dit. You have sounded it out, so then identify that code as C.

Remember, as previously mentioned, do not memorize the order and number of dits and dahs in each code. Memorize the sound of the letters; this makes it easier to receive code.

Flash cards are provided in the Appendix, if you wish to cut them out. Or it is easy to make up a deck of cards using 3- × 5-inch file cards.

PRACTICE WITH LETTER GROUPS

For convenience, Charts 2-2 and 2-3 are included, which can be used for sounding out the letters. Note that the char-

Chart 2-2. Code Groups

Code Group One

E E T T A A R R E T A R
RATE TEA TAR ATE EAT ERA REAR RATE TEA TAR ATE EAT ERA TEAR

Code Group Two

S S L L U U Q Q J J S S L U Q J
SLAT SALE QUART QUEER JUST STAR SQUEAL

Code Group Three

H H O O N N C C V V H O N C V
HOT COAL OVER THE TOO THUS NOT CAVE VENT CENT HER HONE CAT

Code Group Four

I I B B Y Y P P I B Y P
BIT BAY PIT PILL YET YES HELP HAPPY HIP QUIT QUIET

Code Group Five

W W K K Z Z M M D D X X F F G G W K Z M D X F G
DOG FOX WAG EGG WORK MOM KEG ZING DARK MY MAGIC

Code Group Six

1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0 0 1 2 3 4 5 6 7 8 9 0
, , ? ? - - . . , ? - .
1977 1066 1812 704 1492 512 1335

acters are listed first and are repeated several times. Once you have memorized the sound for the letters, then work on the words that are made up of only the letters you have already learned. Once you have mastered these groups or other similar material, you will be ready to listen to cassette tapes, a radio receiver, or other text sent by a friend. (See Fig. 2-3.)

The remainder of the chapter has numerous suggestions about how to proceed once you have memorized the basic codes.

Chart 2-3. Code Practice Text

LEARNING MORSE CODE IS FUN. ONCE YOU LEARN TO SEND AND RECEIVE IT WELL, IT IS JUST ABOUT LIKE ANOTHER LANGUAGE. THE PROS CAN COPY FAST--OVER 20 WORDS PER MINUTE--AND SEND EVEN FASTER. YOU WILL REALLY HAVE A THRILL WHEN YOU MAKE YOUR FIRST CONTACT. GOOD LUCK.

CASSETTE TAPES

Listening to cassette code tapes is straightforward and you can obtain them from various sources and for most code speeds. The key is to have a number of tapes available. If you have just a few, you will memorize the contents quickly and make them ineffective for code practice.

Fig. 2-3. Have a friend *sound out* the code.

Fig. 2-4 shows an aspiring amateur copying a five-word-per-minute code tape. The best approach here is to write out what is heard in longhand instead of printing each letter. Printing takes too long and writing in cursive is usually faster. Also, do not write too big and use ruled paper. After, all, the goal here is to copy the code and keep the writing effort to a minimum.

Whether or not you limit the number of tapes you buy, it is a good idea to have tapes that include cipher groups. Cipher groups are groups of five random letters as listed at the bottom of Chart 2-4. The advantage of the ciphers is that you will not readily memorize them. They are excellent for intermediate code practice.

Fig. 2-4. Listening to code from a cassette.

LISTENING TO W1AW FOR CODE PRACTICE

W1AW is the main station of the American Radio Relay League located in Newington, Connecticut. They transmit code practice messages nearly every hour of the day every day on most amateur bands. If you have or can borrow a receiver for the 80- or 40-meter band, using it to listen to W1AW would be an excellent way to build up your code speed. The code they send is very exact and you can check your receiving accuracy by referring to the source of their text. They always tell you what part of their magazine, *QST*, the text comes from.

The frequency on which W1AW transmits and the time of day code practice is sent for beginners changes from time to time. It would be a good idea to check the Operating News section of the current *QST* for exact times. Generally, W1AW transmits on 3.58 megahertz on the 80-meter band and 7.08 megahertz on the 40-meter band. Refer to Chart 2-5 for time of day and day of the week for code sessions. The next section is helpful in this regard.

Chart 2-4. Typical Code Cassette Message and Ciphers

7½ Words per Minute
Side A

E E T T A A R R S S L L U U Q Q J J E T A R S L U Q J
TEA RATE SALE SQUEAL QUEER JEER
H H O O N N C C V V I I B B Y Y P P H O N C V I B Y P
HOT JEST VENT QUIET BAY HAPPY CHAIR
W W K K Z Z M M D D X X F F G G W K Z M D X F G
DOG FOX ZEBRA QUEST WEAK MAGIC
1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0 0 , , ? ? & & . .
1 2 3 4 5 6 7 8 9 0 , ? &
1492 105,946 NO. 8 YES?
THE 1977 KANTRONICS 8040A PORTABLE RECEIVER IS VERY GOOD.
YOUR 6TH BIRTHDAY? 4,532 WERE A1 OPERATORS IN 17 DAYS.
EXACT FINES WHITE STAMP JUMPS BACKS INPUT LEARN
CHECK DOUBT VINES ZEROS GRATE READY MISTY 72138
MARKS QUOTE ZEBRA QUITE ZQAPS SQLUE QUOAZ KELTD
ZAOMB URIZA 8AO4Z ZOOKS FORTZ FIMLK PATTZ GADOA
AUNIC ZAERD GLAPF CDBOK IM&02 MOZAB BE4OR CLAYP
NPXOB ZOYHC M7E0J BFWDE NCBZD EIZ74 VCCCV PDWFA
O4LYF WDISL FIJ9H CBZNY 0BWDV SWIB5 EKNAY DZBCN
EDWFB J0E7M CHYPZ BOXPN OXDAV HFNDP 3MKMG BB1XA
ED9WN KZIDS NZCUI TKZJL HJRMK KBTMC

FORMAT OF THE CODE MESSAGES FROM W1AW

Code sessions start at the beginning of the hour. W1AW sends their identifying message first followed by the code speed of the message that will come next. The code practice message is then sent followed by the reference for the text. The sessions start at a code speed of 5 wpm. Each session lasts about eight minutes and the session speeds are 5, 5 again, then 7½, 7½, 10, 13, and 15 wpm.

Chart 2-5. Station W1AW Code Practice Operating Schedule

PDST	CDST	EDST	UTC	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
6AM	8AM	9AM	1300	x		x		x		
1PM	3PM	4PM	2000		x		x		x	x
4PM	6PM	7PM	2300	x		x		x		
7PM	9PM	10PM	0200		x		x		x	x

Note: Please check *QST* magazine for schedule and procedure changes. The above schedule is for slow speed code sessions only. W1AW also has fast code sessions and many cw bulletins. UTC means universal coordinated time and CDST means Central Daylight Savings Time.

An approximate example of the text of one of their code broadcasts is shown in Chart 2-6. Some of the terms need explanation. *QST*, as well as being the name of the magazine, means calling all amateurs, and DE means from. So QST DE W1AW means calling all amateurs from station W1AW. The AR at the end of the message means wait because more is to follow. The code for AR is di-dah-di-dah-dit. No space is left between the A and R codes.

LISTENING TO AN AMATEUR RECEIVER FOR CODE PRACTICE

This method of practice is not recommended until you have at least memorized all the letters and numbers and you can receive messages sent by a friend. For one thing, the stations that you listen to may not be sending very good quality code and, in addition, most messages in the Novice bands tend to become repetitive. One can begin to anticipate what the messages are and this will not build code speed. Further, when listening you will often be able to hear only one side of the conversation due to your location. However, it can be helpful if you will be selective and

Chart 2-6. Format of W1AW Code Messages

Approximate example:

QST QST QST DE W1AW W1AW W1AW QST QST QST DE W1AW W1AW W1AW
CODE PRACTICE SESSION--NOW 5 WPM--THE ELECTRICAL CIRCUIT POTENTIAL . . . (rest of practice text) . . . (then some number sequences) . . . 58678 . . . FROM PAGE 56, *QST*, JULY 1977--AR

pick stations that push your receiving speed and seem to have some text mixed in with the usual name and location information. (See Chapter 4 covering Operating Procedures.)

Chart 2-7. A Typical Code Message

Code exchange:

CQ CQ CQ DE WD0BSW KN

WD0BSW WD0BSW DE WB0KDE WB0KDE K

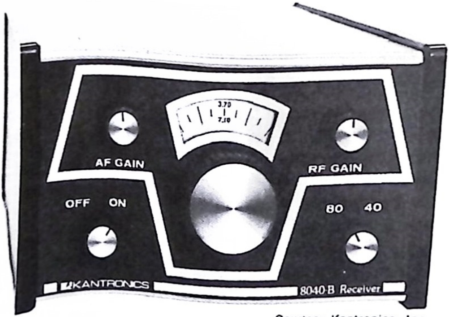
R R R WB0KDE DE WD0BSW--FB COPY OM. UR RST IS 599 IN LAWRENCE, KANSAS. NAME IS PHIL. SO HW COPY? WB0KDE DE WD0BSW K R R R FB PHIL. TNX FER COMING BACK TO ME. THE HANDLE HR IS RICK--THE QTH IS ALSO LAWRENCE, KANSAS. I THINK WE HVE WORKED BEFORE. I MUST QRT FER LUNCH NOW SO 73 ES GUD LUK. WD0BSW DE WB0KDE SK R R R FB RICK. 73 DE WD0BSW SK.

(See Chapter 4 on Operating Procedures for abbreviation definitions.)

Novice frequencies on 80 and 40 meters:

3.700–3.750 MHz on 80 meters, 7.100–7.150 MHz on 40.

Pick and choose to find stations at the speed right for you. Novice bands get extremely crowded in the early evening so it is best to listen late in the afternoon or late at night. For convenience, the Novice portions of the 80- and 40-meter bands are listed in Chart 2-7 along with a typical exchange of code between two stations.



Courtesy Kantronics, Inc.

Fig. 2-5. A typical novice receiver by Kantronics.

LISTENING TO A RECEIVER

You can find several inexpensive receivers on the market; an example is shown in Fig. 2-5. One of the best places to look for bargain units is in the ham magazines. Ads appear from time to time and used equipment is also listed in the classified sections. You could also shop around with local hams or attend some of the regional hamfests to locate a beginner rig.

The receiver shown in Fig. 2-5 tunes the Novice portion of both the 80- and 40-meter bands and is quite simple to install and use. The unit requires two 9-volt batteries, a pair of earphones, and an antenna. Then all you have to do is turn it on, adjust the audio gain (AF), and tune the dial until you hear code being sent. The unit can also be used to listen to W1AW for code practice by turning the band-switch control to 40 meters and tuning the vernier dial to 7.08 MHz.

I think a suggestion is in order here. If you decide to obtain an inexpensive receiver, make sure that you ground the unit to a water pipe and take the time to attach a decent antenna to it as well. The inexpensive units will perform better if you do this. I would also recommend a dipole antenna for the 40-meter band or, at minimum, a long-wire antenna. If you use a long-wire antenna, make it at least 60 feet in length. Attach it to the antenna terminal of the unit and then string it up as high as you can get it outside, if possible. One word of *caution* here, do not hang your antenna near any high-voltage power lines!

You may wonder what a dipole is. A diagram of one is shown in Fig. 2-6. The dipole antenna is an antenna split in two; in other words, you connect two wires from your

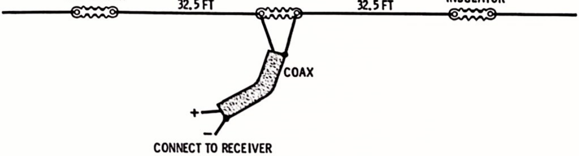


Fig. 2-6. A dipole antenna for 40 meters.

receiver to the center of the dipole and, thus, it is split into two pieces. The two pieces are always cut to a specific length to correspond to a particular amateur band. For 40 meters, the two lengths of wire should each be about 32.5 feet. You then use insulators to tie off the ends of each piece. The higher the dipole is strung above ground the better. If you use one, try to string it at least 30 to 40 feet off the ground.

chapter 3

Sending Morse Code

Although a code-sending test is required only if you take the Novice exam by mail, learning to send good code will help overall in code receiving. In addition, once you have an amateur license, sending good code enhances the enjoyment of operating a station. Above all, good code sent by the transmitting station is appreciated at the receiving end.

The principles that apply to receiving code also apply to sending it. Remember the key to receiving code well is to listen to the sound of the letters instead of picking out the construction of them by dits and dahs. The key to sending good code is to make the sound and rhythm of the letters right and to properly time the duration between letters. Send the code for a letter by thinking and transmitting the *sound of it.*

Fast sending speeds can be developed using this sound method. Do not try sending too fast at first but send at a comfortable speed. If one thinks of the construction of the code and sends the code by individual dits and dahs that make up the code, then speed will be hampered and rhythm may be poor.

So, the principles of sending good code are:

1. Think and send the sound of the letters.
2. Leave a proper duration between letters and words.
3. Send at a consistent speed.

WAYS TO PRACTICE

There are a number of ways to practice sending code. One method is to pick up a magazine or newspaper and think or sound out the code for each letter read or you can consider using a code practice oscillator with a code key. The use of a code oscillator like the one shown in Fig. 3-1 is a good learning method because the code sent will sound like that heard on a cassette or receiver. Directions for constructing your own code oscillator are presented later in the chapter. You might also practice while going to and from work. (See Fig. 3-2.) Each time a street sign is approached, sound out the letters on the sign. STOP—di-di-dit, dah, dah-dah-dah, di-dah-dah-dit. This method can be fun; I enjoyed building up my speed this way.

Fig. 3-1. Sending code can be fun.

Other ways of learning the code have been fun, too. For example, I placed a phone call to a friend and he was not in; the recorder stated that a message could be left after the tone. Well, after that bleep, I sounded out a code message to have him call me back.

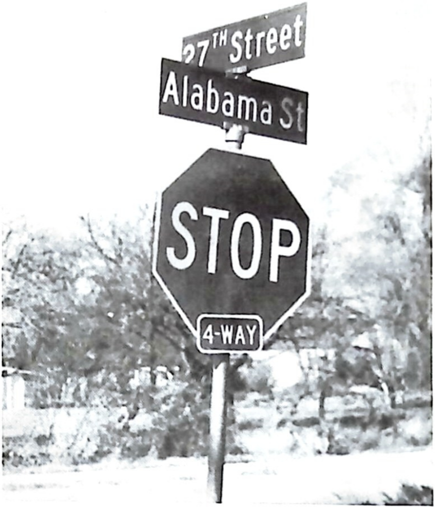


Fig. 3-2. Code the signs to and from work.

INITIAL SENDING PRACTICE

I have found that it is easy to send code smoothly by taking time to warm up a bit. I usually send one or two simple letters repeatedly about ten times. Then, I will send longer codes like those for the letters V and B. It is just like limbering up before exercising.

Warming up on shorter codes works well for the beginner, too; start with the simple codes and build up from there. Chart 3-1 shows the codes for all letters broken into seven letter groups. Each group starts with a simple code and then extends this code to longer codes. For example,

Chart 3-1. Morse Code Sending Groups Practice

Group I T — N —· D —·· B —···	**Group II** E · A ·— U ··— V ···—
Group III M —— O ——— G ——· Z ——·· Q ——·—	**Group IV** I ·· S ··· H ····
Group V K —·— C —·—· Y —·—— X —··— F ··—·	**Group VI** R ·—· L ·—·· P ·——· W ·—— J ·———
Group VII comprises all the numbers.	

consider group I. The letters are ordered so that one letter builds on the next; that is, N follows T, D follows N, and so on. T is the shortest and each code adds a dit to the preceding one. Sending D (—· ·) is easy after sending N (—·) several times. So, the best procedure for practicing is to send each letter in a group several times and then follow with several tries of the next letter. The longer codes will then flow smoothly.

PRACTICING WITH A KEY

Fig. 3-3 shows an aspiring amateur practicing with a key and code oscillator. The scene seems simple enough but look carefully. For one thing, he is seated comfortably. Second, the sending arm is resting on the desk. This should help to avoid cramping and allows the wrist and fingers to do all the work. They can move faster than the whole arm. Third, the key has been adjusted so that its motion is smooth and right for the operator. The all-metal keys, as shown in Fig. 3-4, have a spring adjustment for pressure and a depth adjustment at the end opposite the touch knob. It is the author's opinion that it is better to pay a few extra dollars

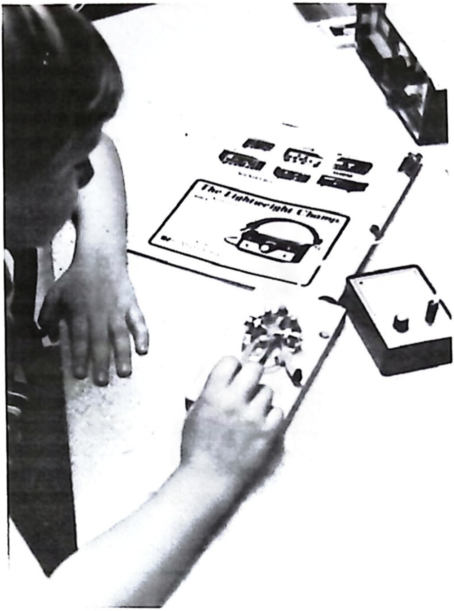


Fig. 3-3. Sending code using a code key.

to purchase one of these keys rather than a plastic version. The plastic units are not easily adjusted, smooth operating, or rugged.

Practicing with a key affords several options. You can record code onto cassette and play it back to evaluate how it sounds. Also, sending along with the code played on a commercial cassette can help with practicing rhythm and spacing. Further, you can record text for receiving practice.

BUILDING A CODE PRACTICE OSCILLATOR

If you do not want to buy a code practice oscillator (cpo) and like to tinker and do it yourself, then consider build-

Fig. 3-4. A code oscillator, brass key, and code cassette.

ing one. All the necessary diagrams to help you are shown in Figs. 3-5 through 3-7 and the completed unit is shown in Fig. 3-8. You will need some basic tools, such as a soldering iron, solder, and the parts listed in Table 3-1. All the parts are readily available at any radio hobby store or through one of the vendors advertising in the amateur radio magazines.

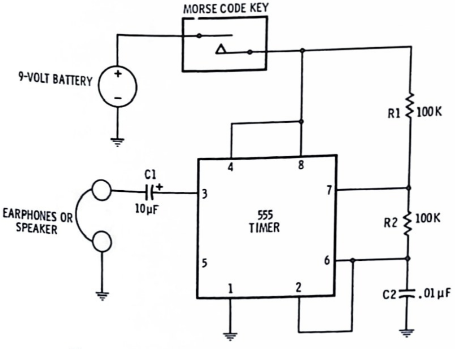


Fig. 3-5. Code oscillator circuit diagram.

Table 3-1. Code Oscillator Parts List

Parts Required	Description
1	9-volt battery
1	Battery clip
1	IC 555 timer
1	IC socket
4	1/2-inch standoffs, 6-32 screws
2	100K 1/4-watt resistors
1	0.01-μF capacitor
1	10-μF capacitor
1	Earphone set or 8-ohm speaker
1	3 × 4 × 1/16 inch perf board
1	Small spool hookup wire

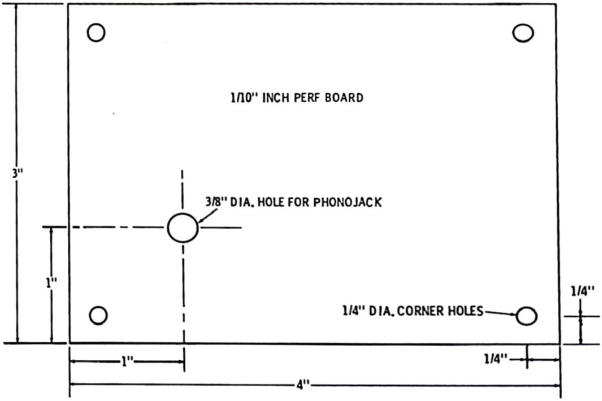


Fig. 3-6. Board layout for mounting code oscillator.

Purchasing a cpo kit, or completed cpo is, of course, an alternative to building one. However, buying the parts individually, planning your construction, and putting the unit together will help you to become familiar with these aspects of electronics. The experience will pay off when exam time arrives.

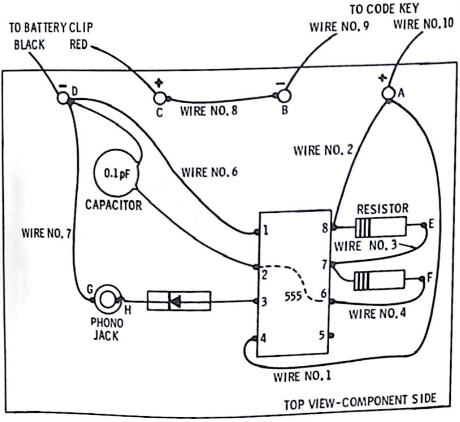


Fig. 3-7. Oscillator wiring diagram.

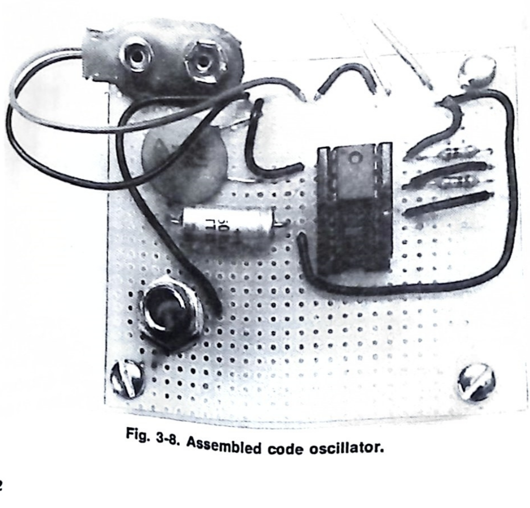


Fig. 3-8. Assembled code oscillator.

PARTS DESCRIPTION

Perf board is thin board that is made of phenolic or epoxy material and perforated with many holes. The holes are punched into the board in various design patterns. You will want to buy the board that is 1/16-inch thick and has holes punched every 1/10 inch all over.

The integrated circuit, IC 555 timer, is a popular IC with electronic hobbyists and should cost less than one dollar. It is called a timer because you can use it to make oscillators or other timing circuits. The IC has eight pins projecting from the bottom of the plastic case and these pins can be plugged into an inexpensive IC socket or stuck directly into the 1/10-inch spaced holes in the perf board for mounting.

The resistors and capacitors used with the oscillator are very common parts. If you are new to electronics, several pictures of these components are shown in the section on electronic components in Chapter 5.

The battery clip listed in Table 3-1 is the kind used with all 9-volt transistor batteries. It has two wires that are attached to a socket that "clips" onto a 9-volt battery. The wires can then be soldered to your circuit. The clips attach to the battery in only one direction. The plus (positive) wire lead (usually red) connects to the plus side of the battery.

STEP-BY-STEP ASSEMBLY

1. Cut a piece of perf board 3 × 4 inches.
2. If you are going to use feet, standoffs, for the perf board, then drill the four 1/8-inch corner holes as shown in Fig. 3-6.
3. If you are going to use a phono jack to connect earphones, then drill a 3/8-inch hole in the board for the jack as shown in Fig. 3-6. Omit this step if you are going to solder connections directly to a speaker.
4. Now you are ready to mount the parts. All the parts should be mounted on the same side of the perf board. Soldering will take place later on the back side where all the wires stick through.
5. Mount the IC socket for the 555 timer at the center of the board. See Fig. 3-7. Push the pins through the

board and bend them out a bit to hold the socket in place.

6. Mount the ¼-inch phone jack if you wish to use it.
7. Mount both of the resistors as shown in Fig. 3-7.
8. Mount the capacitors.
9. Now you are ready to mount the short pieces of hookup wire. Strip ½ inch of insulation from each end prior to mounting and insert the stripped-off portion of the wire through the perf board. These ends will be soldered later.
10. Run wire No. 1 from pin 4 of the IC to the plus position for the code key, point A.
11. Run wire No. 2 from pin 8 of the IC to the plus position of the code key, again point A.
12. Run wire No. 3 from pin 7 to the top resistor, point E.
13. Run wire No. 4 from pin 6 to the other resistor, point F. (There is no wire No. 5.)
14. Mount the 10-μF capacitor between pins 3 of the IC and the center terminal of the phone jack, point H. Note that this is the part that connects to the terminal that extends from the back of the phono jack.
15. Mount wires No. 6 and No. 7 from point D to pin 1 of the IC and point G of the phono jack.
16. Mount wire No. 8 between points B and C.
17. Mount one end of each of two wires, No. 9 and No. 10, to points A and B.
18. Mount the battery clip wires to points C and D. Make sure the plus (usually red) is mounted to position C.
19. This completes the mounting of all components on the top of the board. Now turn the board over and twist the wires together at each point and solder them. Note that each black dot on Fig. 3-7 corresponds to a solder point.
20. Once all wires are soldered, add a jumper wire between pins 2 and 6 of the IC on the bottom of the board. Solder it in place.
21. Check all the wiring and connections of components against Fig. 3-7.
22. Now you are ready to attach the code key, battery, and speaker or earphones to the oscillator. Connect the battery to the clip and the code key to the free

ends of wires No. 9 and No. 10. Order does not matter here.

23. Plug in the earphones and have fun. If you have a problem, recheck the wiring.

CIRCUIT OPERATION

The cpo should generate a tone (frequency) of about 700 Hz. The tone is set by resistors R1 and R2. If the tone is not pleasing, experiment with different values of these two resistors. Volume may be adjusted by adding a potentiometer between pin 3 of the IC and the earphones. If you are a newcomer and not familiar with the term, a potentiometer, sometimes called a pot, is nothing more than a variable resistor.

chapter 4

Operating Procedures and Message Forms

The aspiring amateur should know the basic station operating procedures and the format for Morse code messages. There will probably be a few questions on the Novice written exam on station procedures as well as a receiving code test text that may be in the form of a standard amateur contact message. Knowing the form of the code messages also makes it much easier to listen to or monitor amateurs who are transmitting. On both code and voice transmissions, amateurs use many word abbreviations and message codes called *Q signals*. A Novice tuning in for the first time to listen to amateur broadcasts would not have the foggiest idea about what was being said without understanding the lingo.

OPERATING PROCEDURE

There are three basic operating procedures that should always be followed. Ground all equipment for better operation and safety, be courteous to other operators while transmitting, and periodically check the frequency output of your transmitter.

Grounding your equipment should always be the number one priority in setting up a station. There are several reasons for this. A good ground will provide better reception of weak signals and grounding is the first rule in safety. You should also keep insulating covers on all parts of the station equipment that could cause electrical shock. The best ground for safety purposes is a heavy copper wire connected from the building ground at the electrical box to the chassis of the radio equipment.

The second rule is really just to be courteous. An amateur should not inconsiderately turn on his transmitter and just start sending. The best procedure is to listen first, tuning the receiver dial across the band, to hunt for someone to talk to. Usually someone will already be calling CQ to make a general contact. CQ means, "If anybody hears me, I would like to talk to you." If no one is calling CQ for a contact or the operator desires to do so himself, he should then tune to an open spot on the band and start sending CQ.

Third, amateurs should periodically make a frequency check on their transmission equipment. The frequency of transmission must be kept within the amateur frequency bands. At a minimum, the transmitter frequency should be checked with the station receiver. If this is done, the receiver itself should be calibrated to a frequency standard signal such as that from WWV. WWV is a U.S. Government station in Colorado that transmits a continuous signal on 2.5, 5.0, 10.0, and 15.0 MHz. The frequencies on which these signals are sent are very accurate and can be used as a standard to calibrate your equipment. Incidentally, WWV broadcasts the time of day every minute and gives radio transmission conditions once each hour. Other test instruments such as a frequency calibrator or a calibrated radio-frequency signal generator are available, too, to set the receiver on proper frequency. Many amateurs purchase an inexpensive unit called a crystal calibrator. This unit will transmit signals to a receiver at 50- or 100-kHz intervals on the receiver dial. The units are available from several vendors and are priced from about $39.00 to several hundred dollars. The more expensive receivers and transceivers have a calibrator built in. The point is that the transmission frequency of the station equipment should be checked so that emissions will stay within the lawfully designated amateur bands. Calibrate your station receiver and use it to check the transmitter.

MAKING RADIO CONTACT

An amateur initiates a radio contact with another amateur by first calling CQ and sending his call letters. For example, if I wanted to talk to anybody who would like to respond, I would call, "CQ CQ CQ DE WØXI KN." This means that I am calling for any amateur to respond. You should notice several abbreviations. These are explained in Table 4-1. Once someone hears my call, they will return the message by sending to me my call letters followed by their call letters and a K. This means that they also want to chat. Fig. 4-1 shows a typical amateur station and operator ready to make radio contact.

Table 4-1. Code Abbreviations

Abbreviation	Meaning
ANT	Antenna
AR	End of message (code of letters is run together—no space between A and R)
CPY	Copy
CQ	Calling all amateurs
CU	See you
CW	Code transmission
DE	E.g. DE WØXI means from WØXI
FB	Fine business or great
FT	Feet
HR	Here
HW	How
KN	Invitation to transmit, I am finished
RIG	Equipment you are operating
SK	End of transmission
TNX	Thanks
UR	Your
WX	Weather

MESSAGE FORMAT

The second phase of the QSO, or conversation, is used to exchange basic information such as name, location, and signal report. Since I called for the contact first, I must send the other ham my name, my location, and a report of how his signal sounds to me. Once I have done this, he then

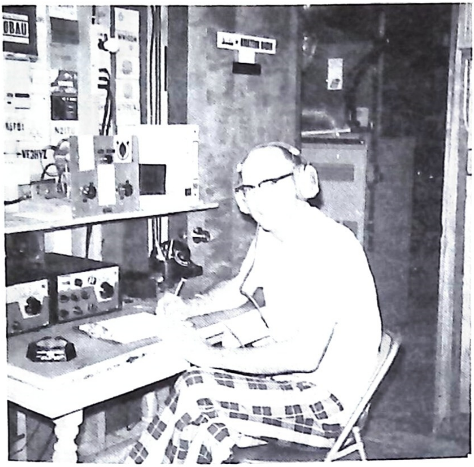


Fig. 4-1. Making radio contact.

sends his basic information. After that we can talk about anything within the rules set by the FCC. Once the QSO is complete, each station signs off the air and is free to look for another contact. In summary, the message format for a radio contact follows:

1. Initiating station calls for contact with CQ and call letters.
2. A second station answers with call letters of both stations.
3. The first station sends call letters, signal report, name, and QTH.
4. The second station does the same.
5. The first station then sends general information such as WX, etc.
6. The second station does the same, etc.

In order to present a detailed example of the above, several definitions and abbreviations must be presented first.

ABBREVIATIONS

Table 4-2 lists the most common code and Q signal abbreviations. Let's form a message using some of these to say, "the weather is fine and did you copy my message?" We would abbreviate the message as "WX hr is fine--and did U cpy my message?" The abbreviated messages can take just about any form you can think of. The point is that when sending code you want to abbreviate as much as possible to shorten the time it takes to send your message.

Table 4-2. Common Q Signals

Q Codes	Meaning
QRM	Interference from other stations
QRN	Static and weather noise
QRP	Lower power or a low power rig
QRS	Please send slower
QRT	Stop sending, must leave
QTH	My location is

The Q abbreviations are used as a short form for a whole predefined message. For example, QTH means "My location is--." Here only three letters need to be sent instead of twelve.

RST—SIGNAL REPORT

Signal reports take the form of three numbers. The numbers stand for the quality level of readability, signal strength, and tone. Readability of a signal is rated on a scale of 1 to 5. A 1 means that the signal is barely readable or understandable and a 5 means that it is perfectly readable. Signal strength is rated from 1 to 9. A 1 rates the signal barely strong enough to hear and a 9 means that it is extremely strong. Tone is also rated from 1 to 9. Signal reports are sent by transmitting RST followed by the number rating for each category. For example, "Your RST is 5-7-9" means the signal is perfectly readable, pretty loud, and has a fine tone. An RST of 3-5-9 would rate a signal as readable, slightly weak, but with a good tone.

QUESTIONS

Q4-1. **What is the best procedure for picking a transmitting frequency?**

Q4-2. **What is WWV?**

Q4-3. **An amateur should periodically check his transmission frequency. How can he do this?**

Q4-4. **What does QTH mean?**

Q4-5. **What does RST mean?**

Q4-6. **How would you define an RST of 1-4-9?**

Q4-7. **What is QRM?**

Q4-8. **Once an amateur has made a contact he sends what three specific pieces of information?**

Q4-9. **What is WX?**

Q4-10. **What is DE?**

Q4-11. **What is ANT?**

ANSWERS

A4-1. *Tune for an open spot on the band.*

A4-2. *WWV is a U.S. Government station that transmits the time.*

A4-3. *With a frequency calibrator or receiver checked with WWV's frequency.*

A4-4. *Location of station.*

A4-5. *RST stands for readability, signal strength, and tone.*

A4-6. *Barely readable, fairly weak strength, and good tone.*

A4-7. *Radio interference.*

A4-8. *The signal report (RST), his name, and location.*

A4-9. *Weather abbreviation.*

A4-10. *It means "from."*

A4-11. *It means "antenna."*

DETAILED MESSAGE FORMAT

Chart 4-1 presents a typical message that an amateur would send during the initial part of a QSO with another amateur. Read *through* it and then substitute the definitions for the abbreviations. A second form of the message is listed, too, and it is a little more formal in format. The call letters of the receiving station are followed by the call letters of the sending station. Then, the sending station gives the RST signal report of the other station, followed by his own QTH and name. Usually this is all that is sent on the second

Chart 4-1. Typical Message Format Using Code

WB0ZDH de W0XI r r r tnx for call. ur RST is 5-7-9--RST is 5-7-9 hr is Lawrence, Kan--Lawrence, Kan. Name hr is Phil--Phil. Rig hr is HW-8. WX is cool and dry. Ant. is dipole 98 ft in the air. So hw cpy? WB0ZDH de WD0BSW AR.

A somewhat more formal form of the same message is:

WB0ZDH de W0XI r r ur RST 5-7-9, QTH is Lawrence, Kan--Name is Phil--Phil. So hw cpy? WB0ZDH de W0XI AR.

NOTE: The 0 with a slash through it, Ø, means that it is a zero and not the letter "O".

transmission. The format of this message may be similar to the one that you may hear when you take your code test. For this reason some questions are included similar to those you may encounter.

Chart 4-2 presents a complete QSO between two stations.

QUESTIONS ON MESSAGE IN CHART 4-1

Q4-12. Who is sending the message?

Q4-13. What kind of rig does he have?

Q4-14. What is the weather at his location?

Q4-15. How high is his antenna?

Q4-16. Did he find the other amateur's signal readable?

Q4-17. What is the name of the operator at the receiving station?

Q4-18. What is the RST of the transmitting station?

Q4-19. What zone is the receiving station located in?

Q4-20. What is the name of the amateur sending the message?

ANSWERS

A4-12. *W0XI is sending the message; his call appears second.*

A4-13. *An HW-8. This is a small Heathkit unit.*

A4-14. *Cool and dry.*

A4-15. *It is 98 feet to the top.*

A4-16. *Perfectly. Why? Because he sent an RST of 5-7-9. Five means readable.*

A4-17. *We do not know yet. We have only heard from the transmitting station.*

A4-18. *We do not know yet. W0XI is sending the RST of the other station.*

A4-19. *He is in zone 0.*

A4-20. *Phil.*

Chart 4-2. ***Text of Complete QSO***

Station #1 calling for contact (to anybody):
CQ CQ CQ de W0XI W0XI W0XI CQ CQ CQ W0XI W0XI W0XI KN.
Station #2 answers:
W0XI W0XI de W0AR W0AR K
Station #1 answers and gives specific information:
W0AR de W0XI r r tnx fer call--ur RST is 5-9-9--5-9-9, QTH is Lawrence, Kansas--Lawrence, Kansas, name is Phil--Phil. Hw Cpy? W0AR de W0XI AR
Station #2 answers and gives details:
W0XI de W0AR r r fb Phil ur RST 5-9-9 in Kansas City, KS and the name is Lee--Lee. W0XI de W0AR AR
Station #1 then returns and talks about weather or whatever:
W0AR de W0XI fb Lee. Gee we are really close here, both in Kansas. Not much of a DX contact but happy to me u. Hi hi. All the hams meet here for coffee on Saturday morning at the motel so come on down if you can--9 AM. Have to QRT now so 73's and gud luck W0AR de W0XI SK
Station #2 then sends his last transmission:
W0XI de W0AR fb Phil. Sorry but I don't drink coffee. We'd like to come for a Danish though. See you Saturday. 73's W0XI de W0AR SK.

chapter 5

Radio Theory

By now you probably have experimented some with Morse code and familiarized yourself with the basic operating procedures outlined in Chapter 4. If so, you only have two more topics to cover in preparation for becoming an amateur. These topics are radio theory and laws governing the hobby.

In this chapter the presentation of radio theory is divided into three parts: radio waves, electrical laws, and electronic devices. Let's start with a look at radio waves.

RADIO WAVES

The key ideas to understand in this section are:

1. speed of radio waves
2. frequency of radio waves
3. wavelength
4. fundamental and harmonic frequencies

SPEED OF RADIO WAVES

Radio waves are used by radio amateurs to communicate with one another over long distances. All radio waves travel at the speed of light, which is 300 million meters per second. It takes only a fraction of a second for a radio wave to travel from New York to California. If you could send a radio wave to the moon and back, the wave would return in just a few seconds. If you could send the wave on a round trip and listen to the return sound as well as the transmitted sound, you could barely hear the difference between them.

FREQUENCY OF WAVES

Because all radio waves travel at the speed of light, some part of each wave must be different so that they can be separated from each other. That difference is called frequency. Your tv set can receive signals from many stations even though the radio waves bringing in each station travel at equal speed. The tv tuning dial does the trick for the operator but the tv set separates the station signals by *frequency*. Each tv station, commercial radio station, or amateur station transmits on a different assigned radio frequency. These frequencies are commonly called *channels*. For your ham radio receiver, the frequencies it can tune to are usually printed on the dial.

There are many waves or signals that have different frequencies in any room of your house. For example, consider the room shown in Fig. 5-1. The electricity from the wall

Fig. 5-1. Sound sources using different radio-frequency signals.

outlet changes or alternates plus and minus 60 times each second. So we say it has a frequency of 60 cycles per second. The present accepted practice in radio and electronics is to call the unit of frequency equal to one cycle per second a hertz and, thus, 60 cycles per second is 60 hertz or 60 Hz, if the abbreviation is used. The radio receives waves that vary between plus and minus one million times each second. You could hear music from the radio speaker that reaches your ear at 2,000 cycles per second. The tv can receive various channels by the waves that arrive having frequencies above 50 million hertz (50 MHz). Light entering the room arrives at an extremely high frequency, 3 million million hertz.

So a frequency of 60 cycles per second means that whatever object or thing you are talking about completed 60 of its operations in one second. The electrical voltage at your outlet changes from zero to plus to minus and back to zero 60 times in one second, and the am radio wave coming from a local station may complete zero to plus to minus to zero one million times in a second. The station signal then has a frequency of one million hertz (1 MHz).

If you were to plot a graph of the voltage coming from your wall socket, it would appear as shown in Fig. 5-2. Start at point A. After the voltage completes one cycle, zero to plus to minus and back to zero, the plot is at point B. After one second the voltage has completed 60 cycles and the plot is at point C.

Fig. 5-2 can also serve as the plot of a received radio-frequency wave. The only difference would be a much lower voltage and a much higher number of completed cycles per second or a higher frequency.

A list of assigned frequencies for the most common radio and television services is presented in Table 5-1. The ab-

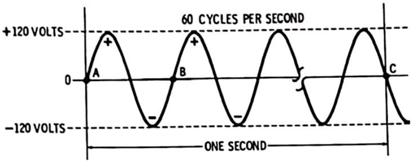


Fig. 5-2. Plot of ac voltage from a wall outlet.

Table 5-1. Assigned Radio Frequencies for Several Radio Services

Type of Station	Frequency in MHz
AM Radio Stations	.5 to 1.6
160 Meter Amateur Band	1.8 to 2.0
80 Meter Amateur Band	3.5 to 4.0
40 Meter Amateur Band	7.0 to 7.3
20 Meter Amateur Band	14.0 to 14.35
15 Meter Amateur Band	21.0 to 21.45
11 Meter CB Band	26.9 to 27.4
10 Meter Amateur Band	28.0 to 29.7
TV Channel 2	54 to 60
TV Channel 6	82 to 88
FM Radio Stations	88 through 108
TV Channel 7	174 to 180
TV Channel 13	210 to 216

Table 5-2. Novice Amateur Radio Frequencies

Band	Frequency in MHz
80 Meter Band	3.70 to 3.75
40 Meter Band	7.10 to 7.15
15 Meter Band	21.1 to 21.2
10 Meter Band	28.1 to 28.2

breviation for one million cycles per second is MHz. Table 5-2 lists the specific frequencies that Novices may use in the amateur radio service.

WAVELENGTH

You may have noticed in Table 5-1 that the Amateur bands were labeled 160 meters, 80 meters, etc. These labels are the approximate wavelengths of radio waves in these

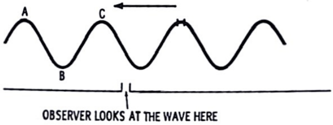


Fig. 5-3. Determining wavelength of radio frequencies.

bands. The wavelength of a radio wave is equal to its speed divided by its frequency. For example, the wavelength of a radio wave with a frequency of 7.0 MHz is 300 million divided by 7 million or 42.85 meters. Another way to define wavelength is that it is the distance a wave travels to complete one cycle as shown in Fig. 5-3. For example, if you could slow down a radio wave and watch it pass a fixed point, at one instant of time point A at the top of the wave passes the point of observation. Then later as the wave moves to the left, point C will be observed. If the distance from A to C is measured, you have the wavelength. The observer would see the wave height at A go down at point B, and then up again at C as the wave passed. When the wave completes one cycle, the *distance* which it travels in that time (traveling at the speed of light) is scientifically termed one wavelength.

If the frequency of a wave is 7.0 MHz it completes 7 million cycles similar to A-B-C in Fig. 5-3 each second. This means the time to complete one cycle would be 1 divided by 7 million. Then the distance traveled in one cycle is the speed of the wave multiplied by the time for one cycle. This is the familiar formula that distance equals rate times time. So the wavelength of a wave is the speed divided by frequency. In summary, the following facts apply to wavelength:

1. Radio waves travel at the speed of light or 300 million meters/sec.
2. The wavelength of a radio wave is the distance it travels in one cycle.
3. The time for one cycle is 1/frequency and the distance a wave travels in one cycle is its rate times the time traveled. Therefore,
4. The wavelength of a radio wave = speed/frequency.

HARMONICS

A harmonic of a radio signal is just another signal with twice or three times the frequency. For example, the second harmonic of a 7.0-MHz signal is 7 × 2 or 14.0 MHz. The third harmonic is 7 × 3 or 21.0 MHz.

QUESTIONS

Q5-1. At what speed do radio waves travel?

Q5-2. What is the speed of a light wave?

Q5-3. If a radio wave has a wavelength of 40 meters, what is its corresponding frequency?

Q5-4. What is the lowest frequency at which a Novice can operate on the 80-meter band?

Q5-5. A kilohertz is how many hertz?

Q5-6. A megahertz is how many hertz?

Q5-7. What is the wavelength of a 7.0-MHz radio wave?

Q5-8. What is the third harmonic of a 3.5-MHz signal?

Q5-9. Do radio waves travel at different speeds?

Q5-10. Does tv Channel 2 operate at a higher frequency than fm radio stations?

Q5-11. If a radio wave travels 40 meters in one cycle, what is its frequency?

ANSWERS

A5-1. ***300 million meters per second.***

A5-2. ***300 million meters per second.***

A5-3. ***300 million divided by 40 meters or 7.5 MHz.***

A5-4. ***3.7 MHz or 3.7 Mc.***

A5-5. ***One thousand.***

A5-6. ***One million hertz.***

A5-7. ***300 million divided by 7.0 MHz or 42.85 meters.***

A5-8. ***Three times 3.5 or 10.5 MHz.***

A5-9. ***No.***

A5-10. ***No. Channel 2 is at 54 MHz and fm stations range from 88–108 MHz.***

A5-11. ***Wavelength = speed divided by frequency, 7.5 MHz.***

ELECTRICAL LAWS

The key terms and principles to understand with regard to the laws of electricity in this section are:

1. voltage
2. current
3. resistance
4. Ohm's law
5. power

6. direct and alternating current
7. inductance and capacitance

Voltage, Current, and Resistance

Voltage is the electrical force that pushes the current through various electronic circuits connecting such components as resistors, inductors, capacitors, transistors, or vacuum tubes. This electrical force can be measured by a *voltmeter* and the amount of force is measured as voltage or volts. Voltage is to electronic circuits as water pressure is to a garden hose that is charged with water.

Current is the electricity that passes through electronic circuits and components. Current is actually the movement of electrons in the wires and devices making up a circuit. Current can be measured by an ammeter in amperes.

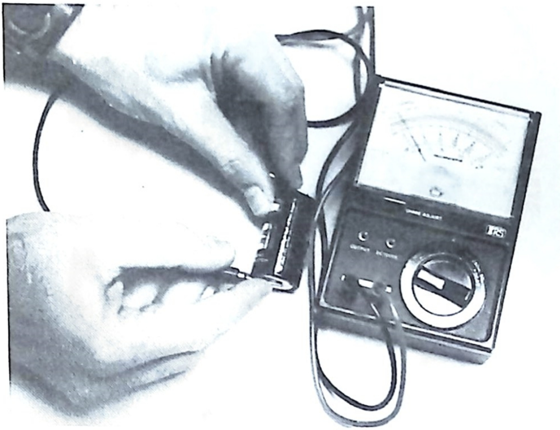


Fig. 5-4. Using a voltmeter to measure voltage.

Resistance is a measure of how much a circuit and the components limit the motion of the current. The circuit is said to have resistance. Normally the resistance of a circuit or component is measured in ohms by an ohmmeter or the resistance can be calculated using Ohm's law.

Fig. 5-4 shows a voltmeter and battery where the voltage *across* the battery is being measured using the minus (negative) and plus (positive) probes of the meter. All dc circuits have polarity, that is a plus and minus side, and voltage is always measured across the circuit. After looking at Figs. 5-4 and 5-5 you will notice that the meter shown is the same one. The meter is called a vom or volt-ohm milliammeter and it can be used to measure voltage, current, or resistance.

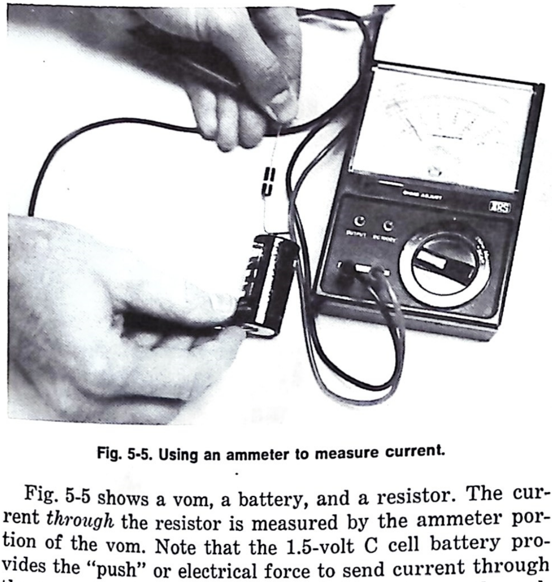


Fig. 5-5. Using an ammeter to measure current.

Fig. 5-5 shows a vom, a battery, and a resistor. The current *through* the resistor is measured by the ammeter portion of the vom. Note that the 1.5-volt C cell battery provides the "push" or electrical force to send current through the meter *and* the resistor. Since the current goes through both the meter and the resistor, the meter measures the same current that passes in the resistor. The current makes a complete path from the negative end of the battery, through the meter, through the resistor, and back through the positive end of the battery to the beginning point. Even when the meter is taken out of the circuit and the battery is connected across the resistor, the same current passes through the resistor as before.

To measure the resistance of an ordinary resistor, one need only place the probes of an ohmmeter across the leads of the resistor. Polarity of the leads does not make any difference because it does not matter which direction the current passes through the resistor.

In summary, voltage is the push or force that causes current in a circuit. Voltage is always measured across a component and current is measured through the component.

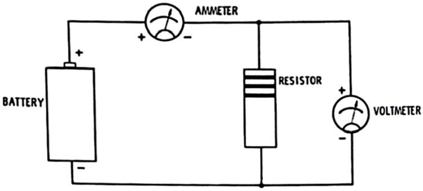


Fig. 5-6. Measuring voltage and current through a resistor.

Suppose you would like to measure both the current *through* and the voltage *across* a resistor in a circuit like the one shown in Fig. 5-6. First, you would connect the ammeter so that there is current through both it and the resistor. This is called connecting them in series. Then, you would connect the voltmeter across (in parallel with) the resistor. Once these connections are made, a reading would be taken from both meters. The plus side of the voltmeter must be connected to the plus side of the resistor which is nearest the plus side of the battery. Otherwise the meter will try to read backward and the needle will just stay at zero or the meter may be damaged. The plus side of the ammeter must be attached to the plus side of the battery, too.

Ohm's Law

Ohm's law describes the relationship between current through a resistor and the voltage across it. Another way to say it is that Ohm's law explains how voltage and current work together with a resistor. Ohm's law states that the voltage across a resistor divided by the resistance of that resistor is equal to the current through the resistor. In formula form this would be voltage/resistance = current. Another way to state Ohm's law is that the current through the resistor times the resistance of the resistor equals the voltage across the resistor. This is written in short form as:

$$I = \frac{E}{R}$$

where,

I is the current in amperes,
E is the voltage in volts,
R is the resistance in ohms.

For example, if we have a 1.5-volt battery and a 1-ohm resistor, then the current through the resistor will be 1.5/1.0 or 1.5 amperes. Take a look again at Fig. 5-6. Suppose that the battery is 1.5 volts and the resistor is a 1-ohm resistor. The current will then read 1.5 amperes and the voltage will read 1.5 volts.

Before we work through a few more examples using Ohm's law, a few definitions are required. In most battery-powered and low-voltage circuits, currents will be low and typical values will be a small fraction of an ampere. For this reason the term milliampere is often used. A milliampere is equal to one-thousandth of an ampere. Defining it the other way around, one ampere is equal to 1,000 milliamperes. The milliampere is usually written in the abbreviated form as mA. Also in battery-powered circuits, most of the resistance values tend to be in the thousand-ohm range. For this reason, 1,000 ohms or one kilohm is abbreviated as 1k. A 2,500-ohm resistor would be equal to a 2.5-K resistor.

Examples Using Ohm's Law

If we have a voltage of 12 volts across a 1,000-ohm resistor, what is the current through the resistor? E/R is the current. So 12/1,000 equals 12 mA (milliamperes). This can also be written as 0.0012 ampere; however, this is not done often. Suppose we have 12 volts across a 100-ohm resistor. What is the current? Again 12/100 or 12 volts/100 ohms is 120 mA. Suppose that the current and voltage in a resistance circuit are known. What is the resistance? Say that the voltage is 12 volts and the current 1.2 mA, what is the resistance? The answer is 12 volts/1.2 mA = 10K or 10,000 ohms. Suppose that the current and the resistance of a circuit are given. What is the voltage across the resistor? Again, E = I × R. Let I = 1.2 mA and R = 5K. That is, let the current be 1.2 milliamperes and the resistor be 5,000 ohms. Then the voltage is 1.2 mA × 5K or 6 volts. (0.0012 × 5,000 = 6 volts.)

QUESTIONS

Q5-12. State Ohm's law.

Q5-13. What is voltage?

Q5-14. What is a mA?

Q5-15. A 1-K resistor is how many ohms?

Q5-16. If a 1-K resistor has a 0.1-ampere current through it, what is the voltage across it?

Q5-17. If a 10-K resistor has 10 volts across it, what is the current through it?

Q5-18. A 5-K resistor has 10-mA current through it; what is the voltage?

Q5-19. Voltage and current for a resistor are 1 volt and 10 mA. What is the resistance of the resistor?

Q5-20. Is voltage measured through a resistor?

ANSWERS

A5-12. $E = I \times R$.

A5-13. *The electrical force or push.*

A5-14. *A milliampere or 1/1,000 of an ampere of current.*

A5-15. *1,000 ohms.*

A5-16. *100 volts.*

A5-17. *1 mA.*

A5-18. *50 volts.*

A5-19. *100 ohms.*

A5-20. *No. Voltage is measured across a resistor.*

ELECTRIC POWER

Power is a measure of how much energy is used in an activity for a given length of time. In electronic circuits power is measured as the amount of electrical energy used per second. For example, in a battery-resistor circuit the voltage forces a current through the resistor. The current heats the resistor which in turn gives off heat. The energy supplied per second that turns to heat is the power.

A similar situation occurs with the common lamp. Standard house voltage forces current through the light bulb which then glows. The bulb gets hot and gives off heat. This is how the bulb gets rid of the energy supplied to it. The heat and light continue as long as there is current. The power supplied to the bulb depends on the bulb wattage rating. Common bulbs are rated at 40, 60, or 120 watts.

Electrical power is measured in *watts*. When a resistor has voltage applied across it, current flows and the power heating the resistor can be calculated by voltage times current. That is, the voltage across the resistor times the current through it equals the power heating it. In short form this is written as:

$$P = E \times I$$

where,

P is the power in watts,
E is the voltage in volts,
I is the current in amperes.

For example, a 9-volt battery can deliver 1 watt to an 81-ohm resistor. How? By Ohm's law the current through the resistor is 9 divided by 81 or 1/9 ampere. The power in watts to the resistor is then E × I or 9 × 1/9 which is 1 watt. The power delivered to an 8,100-ohm resistor would be 9 × 9/8100 or 0.010 watt. This is ten-thousandths of a watt or ten *milliwatts*.

Power used by the resistor in a circuit can be calculated as E × I or I × I × R which can be written $(I)^2 \times R$. Chart

Chart 5-1. Power Expended in a Resistor Using Ohm's Law Formula

1. $P = E \times 1 =$ watts.
   E = voltage across the resistor
   I = current through the resistor
2. $E = 1 \times R$, Ohm's law, so substitute $1 \times R$ (2.0) into (1.0) and
3. $P = I^2 \times R =$ power in watts.
   The square of the current through the resistor times the resistance in ohms is the power used by the resistor.

5-1 explains how the second formula is derived from the first.

DIRECT AND ALTERNATING CURRENT

A direct current refers to the kind of current produced by a battery. Alternating current is the kind of current that is produced by a power generator and is supplied from a transformer to a standard wall outlet. Direct current in a battery-resistor circuit passes in one direction; it moves from the negative side of the battery through the resistor to the positive side of the battery. This direct current, abbreviated dc, is also called conduction current. Alternating current, abbreviated ac, moves alternately in one direction and then the opposite direction in the wires 60 times each second. Electricians call this 60-cycle ac voltage.

Radio waves also generate alternating current. When a radio wave arrives at an antenna the electric field generates a voltage on the antenna. The voltage in turn generates an alternating current in the wires. This current alternately moves in one direction and then the other at the radio frequency of the incoming wave. All rf signals are ac.

Power supplied for receivers and transmitters must be dc; that is, they require a dc supply at a specified voltage rating. The dc voltage can be obtained from the ac outlet by rectifying and filtering the ac voltage. Rectifying the ac in effect changes ac to dc. All electronic appliances such as a tv, stereo, or plug-in radio, have such a rectifier circuit, commonly referred to as the power supply.

INDUCTORS AND CAPACITORS

All radio equipment incorporates the use of inductors and capacitors. Together various arrangements of inductors (coils) and capacitors provide the means for selecting or filtering out one radio wave from among many. For example, an am radio receives all the am stations at the same time at its antenna because the radio waves of each station are present. But a capacitor and inductor at the antenna end of the radio help to pick out only one station. Generally the tuning dial of the radio changes the value of a variable capacitor. The capacitor with the coil then selects the station frequency the radio detects.

Both capacitors and inductors store energy obtained from radio waves. When combined, electronically, they form a resonant or vibrating circuit in which the capacitor and inductor trade the stored energy back and forth. This kind of circuit is also called a tuned circuit. The key fact to remember is that a capacitor and an inductor together trap or store energy obtained from the radio waves.

The value of a typical capacitor in a radio circuit is measured in picofarads, abbreviated pF or "puff" in ham lingo. One picofarad is equal to one-millionth of one-millionth of a farad. Typical values for capacitors range from 50 to 500 pF. Several commonly used capacitors are shown in Fig. 5-7. The unit at the left is called a variable air capacitor. The capacitance of this type capacitor is determined by the number, dimensions, and spacing of the metal plates. The capacitor second from the left is also variable and its value is set by rotating the wafer with a screwdriver. The unit has a range of 10 to 110 pF. The dark, glossy capacitor is a dip mica type that has one specific value. The capacitor

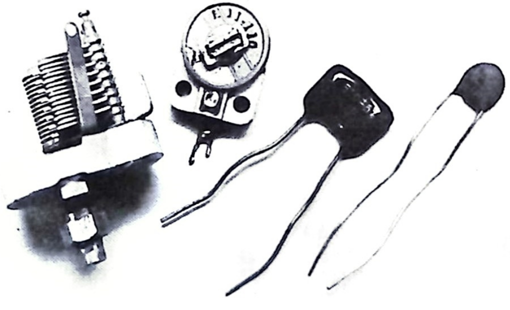


Fig. 5-7. Typical capacitors used in radio circuits.

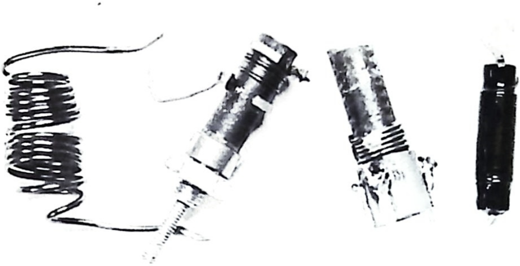


Fig. 5-8. Typical radio-frequency coils.

shown at the right is from a common variety called a ceramic capacitor. Ceramics have fixed picofarad values and can be purchased in values from 10 through 10,000 pF.

The values of inductors in radio circuits are measured in microhenrys. One microhenry is equal to one millionth of a henry. Fig. 5-8 shows four typical inductors or coils used in radio circuits. The coil at the left is an air wound unit. It has an inductance value of approximately one microhenry. The two coils in the center are slug-tuned; that is, they have powdered iron slugs that can be turned in or out of the coil winding with a tuning tool or screwdriver to vary the inductance. The inductance ranges from about 1 to 10 microhenrys. The dark coil at the right is wound on top of a resistor and is called a choke. Generally chokes have a much higher inductance than other inductors used in radio circuits.

QUESTIONS

Q5-21. What do inductors (coils) and capacitors generally do in a radio?

Q5-22. What is a microhenry?

Q5-23. Can inductors store energy from radio waves?

ANSWERS

A5-21. *Together they select a specific frequency from among many striking the radio antenna.*

A5-22. *A microhenry is one millionth of a henry and is the value of a typical radio-frequency coil.*

A5-23. *Yes.*

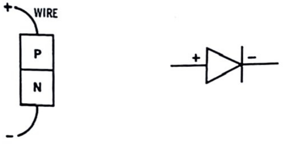
RADIO CIRCUIT DEVICES

The devices used in amateur radio equipment and discussed in this section are: diodes, npn and pnp transistors, FET transistors, and triode tubes. For exam purposes it should only be necessary that you name the various devices and identify their drawing symbols. But, some information on the construction and operation of these devices is also included here.

Diodes and Transistors

Diodes are used in practically all radio receivers and transmitters. The diode is a device used to block current in one direction and allow current to pass in the opposite direction. Diodes are often used to convert ac voltages and currents to dc.

Small diodes are made of p- and n-type semiconductor materials. These are special materials that have electrical properties which lie between insulators and conductors. The diodes are made by stacking a sandwich of p material on n material and attaching wires to each end as shown in Fig. 5-9. The drawing symbol for a diode is shown at the right. If a positive voltage is applied to the plus side of the diode, current will pass from the plus wire through the p

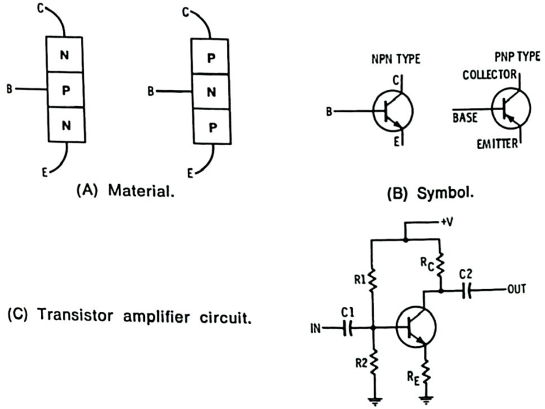


(A) Material. (B) Symbol.

Fig. 5-9. The semiconductor diode.

to the n material and out the minus wire. This is called forward biasing. Current will not pass if a dc voltage is applied backward or the diode is back biased. That is, there will be no current if the plus side of a battery is applied to the minus side of the diode. Proper polarity must be observed.

Transistors are three-terminal devices that are used primarily to amplify signals. They are made from combinations of p- and n-type semiconductor materials, too. The p and n material is alternately stacked to form a sandwich as shown in Fig. 5-10A. The terminals of the transistor are labeled b, c, and e or base, collector, and emitter. The base is the center material. If the base is made of n-type material, then the collector and emitter are made of p-type material. The transistor is enclosed within a metal can or plastic package with three leads extending out the same side. Fig. 5-11 shows a variety of transistor packages. A very common small-signal transistor, the PN2222, is shown at the left and is packaged in plastic. The one shown in the center is a low-power transistor that is enclosed in a metal can. A typical power transistor is shown at the right.



(A) Material.

(B) Symbol.

(C) Transistor amplifier circuit.

Fig. 5-10. An npn and a pnp transistor.

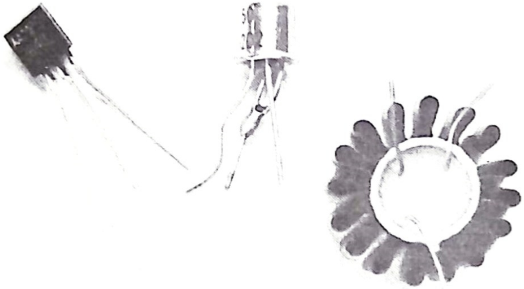


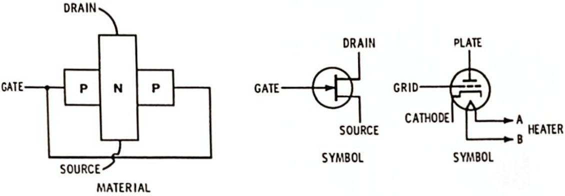
Fig. 5-11. Typical transistors.

Electrical symbols for the npn and pnp transistors are shown in Fig. 5-10B. The npn symbol has an arrow pointing outward at the emitter; the arrow for the pnp points toward the base. The arrow is used to show which way the current passes when the transistor is operating. Output current passes from collector to emitter in an npn transistor and in the opposite direction for pnp types. A signal current passing into the base of either type transistor is amplified and a correspondingly larger signal current passes between the collector and the emitter.

A typical transistor amplifier circuit is shown in Fig. 5-10C. Signals to be amplified enter at the left. Resistors R1, R2, and R_e bias the transistor for proper operation. That is, these transistors are chosen so that proper dc voltages are applied to the transistor. The signal entering the transistor then passes through capacitor C1 and is amplified by the transistor. Voltage amplification is approximately R_c/R_e.

Field-Effect Transistors

Some of the newer amateur radio receivers and very high frequency equipment use the field-effect transistor, abbreviated FET. The FET is made of semiconductor material just as other solid-state diodes and transistors are. However, the materials are stacked differently and a FET can be constructed several ways. As shown in Fig. 5-12A, the n material is sandwiched between connected pieces of p material. The resulting device has three terminals that are called the gate, the source, and the drain.



(A) FET.

(B) Triode.

Fig. 5-12. Field-effect transistor (FET) and triode vacuum tube.

The FET is commonly used for voltage amplification. A signal voltage to be amplified is applied between the source and the gate and the amplified result appears between the source and the drain.

Tubes

Vacuum tubes are still used in many home entertainment units. In particular, television sets still have many tubes including the picture tube. Even though most new amateur radio equipment is solid-state (using transistors only) there are some transmitters being built with tubes. Also, many surplus and used pieces of communications gear have tubes, primarily for high-power transmitters.

One of the most commonly used small tubes is the triode. It has three signal terminals which are used for circuit operation. Fig. 5-12B shows a drawing symbol for the triode. The terminals are called the grid, plate, and cathode. The terminals labeled a and b are filament leads and these do not connect to the radio-frequency portion of the circuit. Input voltage is applied between the cathode and grid and the amplified result is taken from the plate.

QUESTIONS

Q5-24. Draw the symbol for an npn transistor.

Q5-25. Name the terminals of a pnp transistor.

Q5-26. What is semiconductor material?

Q5-27. Can dc current flow backward in a forward-biased diode?

Q5-28. What is an FET?

Q5-29. Name the terminals of an FET.

Q5-30. What is a triode?

Q5-31. What materials are used to make solid-state diodes?

ANSWERS

A5-24. ***See Fig. 5-10B. The arrow points away from the base.***

A5-25. ***Base, collector, and emitter.***

A5-26. ***A material that has electrical properties midway between those of an insulator and a conductor.***

A5-27. ***No. A positive voltage applied to the plus side of a diode causes current to pass only from the plus side through to the minus side.***

A5-28. ***A field-effect transistor.***

A5-29. ***The gate, drain, and source.***

A5-30. ***An amplifier tube.***

A5-31. ***P- and n-type semiconductor materials.***

chapter 6

Rules Governing Amateur Radio

Because of the limited technical knowledge required and because all amateurs should know the FCC rules and regulations, there are bound to be several questions on the Novice exam regarding regulations.

The Communications Act of 1934, passed by Congress, set up the Federal Communications Commission (FCC) to regulate communication by wire and radio. The Act gave the FCC complete control over licensing and regulation of all radio stations. It would take a long time and a good deal of paper to present all of the 1934 Act and amendments to you. It is likely that you would get bogged down in the reading of it, too. So instead, only selected parts that are particularly applicable to amateur radio are presented in this chapter. Chart 6-1 diagrams some of the portions of the main act and Chart 6-2 presents the essentials of Part 97 which specifically sets out rules and regulations which govern communications in the Amateur Service.

The words Amateur Service mean that group of radio stations and operators that are licensed for amateur privileges. Historically, the amateurs have provided communications in times of emergency and for other public services. Also, Part 97 of the rules specifies public service as one of the

Chart 6-1. U.S. Regulations/Communications Law

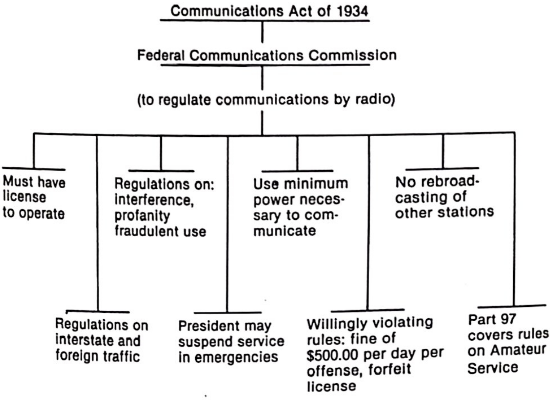

Communications Act of 1934
Federal Communications Commission
(to regulate communications by radio)
Must have license to operate
Regulations on: interference, profanity fraudulent use
Use minimum power necessary to communicate
No rebroadcasting of other stations
Regulations on interstate and foreign traffic
President may suspend service in emergencies
Willingly violating rules: fine of $500.00 per day per offense, forfeit license
Part 97 covers rules on Amateur Service

Chart 6-2. Rules and Regulations Governing Amateur Service

<table>
<tr><th colspan="6">Part 97 of the Communications Act of 1934
Governing Amateur Service</th></tr>
<tr><td colspan="2"><i>Subpart A</i>
Purposes:
public service
encourage and improve skills
Definitions:
operator
operator license
station license
control operator</td><td colspan="2"><i>Subpart B</i>
Licenses:
classes of license
privileges
Novice class:
250-watts power
cw only
application
Form 610 FCC
exams
mail exams</td><td colspan="2"><i>Subpart C</i>
Technical standards:
frequencies
power
emission type A1 only</td></tr>
<tr><td colspan="3"><i>Subpart D</i>
Operating Requirements:
operator is responsible
availability of license
identification on air
one-way transmissions</td><td colspan="3"><i>Subpart E</i>
Prohibited:
remuneration
broadcasting
music
codes or ciphers
obscenity
interference</td></tr>
</table>

reasons for licensing amateur stations. So that is why the word *service* is used in Amateur Service. Fig. 6-1 highlights this purpose of amateur radio; the ham operator pictured is relaying a message.

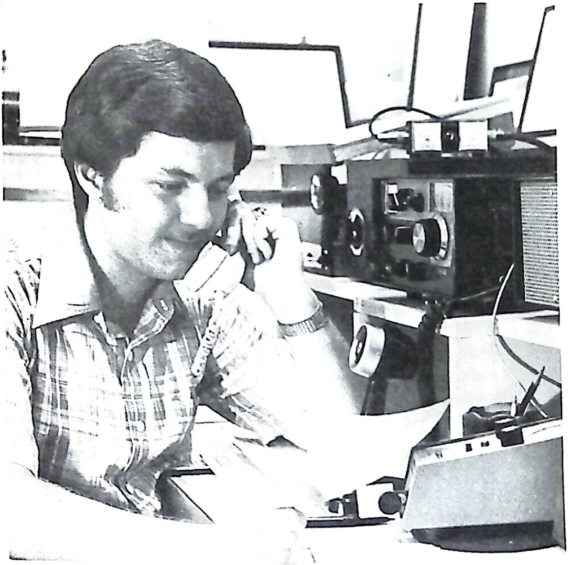


Fig. 6-1. Relaying a message—a public service.

The 1934 Act has seldom been amended until recently when some points in the rules and regulations on the Amateur Service were changed. After reviewing and studying the material presented here and before taking your exam, it would be a good idea to read the "news from Washington" section of several of the amateur magazines to see if any new changes have been made in the rules. From a practical standpoint, very recent rule changes will not be found on already printed exams.

BASIC RULES

The basic rules diagrammed in Chart 6-1 are listed in more detail below but not necessarily in exactly the same wording or order as they appear in the actual regulations.

1. You must have a license to operate a radio station.
2. The Commission can make reasonable regulations regarding interference, sale, import, etc., of radio equipment. The Commission can lift the license of a station upon sufficient proof that the operator(s) have violated the law. The Commission has the authority to inspect all radio stations. You can lose your license for using profane language or using your station for fraudulent means.
3. Station licenses will not be granted to aliens.
4. All transmission equipment must be operated only by a person with a properly authorized operator's license for that equipment.
5. You should use minimum power necessary to carry out the communication desired.
6. You must not rebroadcast a program of another station (any part). Also, you must not issue fraudulent signals of distress.
7. You must not willingly and knowingly violate the rules. If you do, upon conviction, it could cost you $500.00 for each day during which each offense occurred.
8. Messages received or sent for others must not be divulged except to the addressee or his agent.
9. Upon proclamation, due to an emergency, the President may suspend the rules and radio operation, remove equipment, or specify use of equipment by a government agency. Use must be accompanied by just compensation to the owner.

PART 97 RULES ON AMATEUR SERVICE

Part 97 of the rules relates specifically to the Amateur Service, and its rules are outlined in some detail below. The wording and order of the information is not exactly the same as in the actual publication, but is summarized for its intent.

Subpart A. Purpose and Definitions

The basis of this part is to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

a. Recognition of the value of the amateur service to the public, particularly with respect to providing emergency communications;
b. Advancement of the state of the art of radio;
c. Encouragement and improvement of service through rules which provide for advancing skills—technical and communication.

Definitions:

a. An amateur radio operator is a person interested in radio technique solely with a personal aim and without pecuniary interest, holding a valid FCC license to operate amateur radio stations. (In other words you cannot sell items while talking over the air on your radio.)
b. An amateur radio license is the instrument of authorization issued by the FCC comprised of a station license and also incorporating an operator license. (The printed license you receive is the legal paper from the FCC that allows you to operate a station.)
c. An operator license is the instrument of operator authorization including the class of operator privileges. (If you earn the Novice rating, that fact will be printed on your license.)
d. A control operator is an amateur radio operator designated by the licensee of an amateur radio station to also be responsible for the emissions from that station. (In other words, the control operator is the person at the transmitter. He could be the station owner's friend who is also an amateur.)

Subpart B. Operator and Station Licenses

a. The classes of licenses are listed and the privileges of each license are also presented in the full text of Part 97. License classes are Novice, Technician, General, Advanced, and Extra.

b. Novice Class:

Those amateur privileges designated and limited as follows:

- i. Power input to the transmitter final stage must not exceed 250 watts;
- ii. Radio telegraphy is authorized in the frequency bands 3700-3750 KHz, 7100-7150 KHz, 21,100-21,200 KHz, and 28,100-28,200 KHz, using A1 (Morse code) emission only;
- iii. Application for a Novice Class communication license and the appropriate proficiency test must be made on FCC Form 610;
- iv. The rules specify when exams are required and what exams must be taken; the Novice is required to take exam elements 1 (A) and 2 which are the 5 wpm code test and the test on basic law comprising rules and regulations essential to a beginner's operation.
- v. Mail exams. A volunteer examiner must be at least 21 years of age and the holder of a General Class or higher grade of license. He may administer the exam to the applicant. Within 10 days after passing the required code test, an applicant shall submit an application (Form 610) to the FCC office at Gettysburg, Pennsylvania 17325. The applicant shall include a written request from the volunteer examiner for a Novice written exam. All names, addresses, and the license data of the examiner must accompany the request. The volunteer examiner must also state that the applicant has passed the 5 word per minute code test.

  The exam papers will be sent only to the examiner. He will be responsible for proper conduct of the exam and return the exam within 30 days after the date the FCC sent it to him. A score of 74% will be passing for the exam and Commission personnel will grade the exam. A person is eligible for reexamination after 30 days.

Subpart C. Technical Standards

Authorized frequencies and emissions are covered in this section. Also, the maximum authorized power is set for each class of license on each of the amateur bands. Further, purity and stability of emissions required are set.

Subpart D. Control Operator Requirements

a. The licensee of an amateur station shall be responsible for its proper operation.

b. The original license of each amateur station or a photocopy thereof shall be posted in a conspicuous place in the room occupied by the licensed operator while the station is being operated at a fixed location or shall be kept in his personal possession.

c. Station identification must be made by using the call sign at the end of each transmission or exchange of transmissions not to exceed 10 minutes.

d. One-way communication is permitted in such cases as transmission intended for persons learning or improving proficiency in Morse code. (The idea here is that one amateur can send code and others can practice receiving and they need not transmit in return.)

Subpart E. Prohibited Practices

a. One cannot take any remuneration for the use of his station.

b. An amateur station must not be used for broadcasting, that is, the dissemination of radio communications intended to be received by the public.

c. Third party traffic is allowed only with countries that have assented to such practice with the United States. (Third party traffic means sending a message between two amateurs for a third person.)

QUESTIONS

Q6-1. Can an alien obtain an amateur station license?

Q6-2. Can your station be inspected by the FCC?

Q6-3. How much power should be used when communicating with another amateur station?

Q6-4. What is the maximum fine for violating the rules, once convicted?

Q6-5. **What is the definition of an Amateur Radio Operator?**

Q6-6. **What is the definition of an Operator License?**

Q6-7. **What is a Control Operator?**

Q6-8. **What frequencies may the Novice operate on?**

Q6-9. **What is the limit on power to the final amplifier for a Novice operator?**

Q6-10. **Who is responsible for the proper operation of an amateur radio station?**

Q6-11. **How often during operation must an amateur identify his station with his call letters?**

Q6-12. **What kind of music can be broadcast on an amateur station?**

Q6-13. **What kind of cipher groups are allowed? (A cipher group is a coded message.)**

Q6-14. **What part of the FCC rules govern the Amateur Radio Service?**

Q6-15. **What are the emission privileges of a Novice Class licensee?**

ANSWERS

A6-1. ***No.***

A6-2. ***Yes.***

A6-3. ***Use the minimum power necessary to adequately communicate.***

A6-4. ***$500.00 per day per offense.***

A6-5. ***See Part 97, Subpart A.***

A6-6. ***See Part 97, Subpart A.***

A6-7. ***See Part 97, Subpart A.***

A6-8. ***See Part 97, Subpart B.***

A6-9. ***250 watts.***

A6-10. ***The person who received the license for the station.***

A6-11. ***At least every 10 minutes.***

A6-12. ***None.***

A6-13. ***None.***

A6-14. ***Part 97 of the Act.***

A6-15. ***A1 emission only or code which is called CW.***

chapter 7

Taking the Exam

Applicants for the Novice class license are required to take a code test, exam element 1(a), and a written test, exam element 2, on rules, regulations, and some basic radio electronics concepts. The code test, whether administered by the FCC or by a volunteer examiner, must be passed before the written exam can be taken. If the applicant passes the receiving code test at an FCC facility (no sending test is required there), then the written exam is taken immediately and graded upon completion. The 610 form and test results are then forwarded to Gettysburg to the FCC so that a license may be issued. If the applicant takes and passes the code test from a volunteer amateur examiner, who must have a General-class or higher grade of license, then the 610 form must be mailed within 10 days, requesting the written exam. The exam will then be mailed to the volunteer examiner and it must be given to the applicant within 30 days of the FCC mailing date or mailed back unopened. One note of caution—be certain all necessary information is filled out on the forms and make sure the volunteer provides all qualifying information.

TESTMANSHIP

The written exam will consist of about 20 multiple-choice questions. The following suggestions are guidelines you should use to avoid problems.

1. Make sure all information on the form is correct, such as your name, date, examiner's name, call letters, etc.
2. Take plenty of time. Remember that 10 extra minutes during the exam may help you to avoid waiting 30 days to take the exam again.
3. The questions are multiple choice. If you are not sure of the answer, eliminate those answers which are obviously incorrect and guess the most correct one from those that remain.
4. Remember, too, that your first choice or answer is usually the best one. Hesitate to change an answer after picking one.
5. Some questions may appear to have two or even three "good" answers. You have to figure which answer fits the rules and regulations best from the point of view of the FCC. That answer will be the "right one."
6. Double check that you have marked *your* answer in the right column on the sheet. You may know the material but "goof" due to a clerical error. Do not do this!
7. You need only 74% to pass, so do not worry if you cannot answer some of the questions with 100% certainty.
8. If you are uncertain about some procedure on the exam, ask the volunteer. There is no penalty for doing so.

SAMPLE QUESTIONS AND ANSWERS

There are sample questions and answers in Chapters 3 through 6. If you can answer those questions and the ones in the two sample tests listed next, then I think you will be ready for the Novice written exam.

Sample Test No. 1—Novice

If I were assigned the job of writing the exam, these are the questions I would ask.

Q7-1. Can a Novice transmit with emission type A1?

Q7-2. What are the frequencies on which a Novice can transmit on 80 and 40 meters?

Q7-3. What is the definition of a control operator?

Q7-4. Where should your license be kept?

Q7-5. What is the speed of radio waves?

Q7-6. How often should you identify your station while on the air?

Q7-7. What does the abbreviation DE mean?

Q7-8. What is WWV and why do amateurs make use of it?

Q7-9. What does QTH mean?

Q7-10. What is RST?

Q7-11. What is the best procedure for picking a transmitting frequency?

Q7-12. What is the approximate wavelength of a 7.1-MHz radio signal?

Q7-13. What is a kilocycle? A kilohertz?

Q7-14. What is the third harmonic of a 3.5-MHz signal?

Q7-15. What do the abbreviations dc and ac stand for?

Q7-16. How does one calculate the power dissipated in a resistor?

Q7-17. What are the names of the leads on an npn transistor?

Q7-18. State Ohm's law.

Q7-19. If a 9-volt battery is placed across a 9-ohm resistor, how much current will pass through the resistor?

Q7-20. What is a milliampere?

Answers to Sample Test No. 1

A7-1. *Yes, this is cw or code.*

A7-2. *3.700–3.750 MHz on 80 meters and 7.100–7.150 MHz on 40 meters.*

A7-3. *He or she is the person at the transmitter controlling what goes out on the airways.*

A7-4. *Posted at your fixed station or kept with you.*

A7-5. *300 million meters per second.*

A7-6. *At least every 10 minutes.*

A7-7. *DE means from.*

A7-8. *WWV is the government station in Colorado that transmits a signal of very accurate frequency. Amateurs use this signal to align their equipment for frequency accuracy.*

A7-9. *It means your location while transmitting.*

A7-10. *This is the signal reporting system of readability, strength, tone.*

A7-11. *Look for an open spot on the band.*

A7-12. *40 meters.*

A7-13. *A kilocycle is one thousand cycles. A kilohertz is one thousand cycles per second.*

A7-14. *It is three times 3.5 or 10.5 MHz.*

A7-15. *Direct current and alternating current.*

A7-16. *Multiply the current twice times the resistance or* $I \times I \times R$.

A7-17. *Emitter, base, and collector.*

A7-18. *Voltage equals current times resistance.*

A7-19. *The current is 1 ampere or 9 volts divided by 9 ohms.*

A7-20. *One thousandth of an ampere.*

Sample Test No. 2—Novice

Q7-21. What is the maximum penalty, upon conviction, for violating the rules?

Q7-22. Can an alien obtain an amateur station license?

Q7-23. What is the maximum transmission power a Novice can use?

Q7-24. What frequencies can the Novice use on the 15-meter band?

Q7-25. What kind of music can you broadcast on an amateur station?

Q7-26. What is the relationship between frequency and wavelength?

Q7-27. What is the second harmonic of a 7.1-Megahertz radio signal?

Q7-28. What is the frequency of an 80-meter Novice signal?

Q7-29. Can you transmit on the 20-meter band with a Novice license?

Q7-30. What does QRS mean?

Q7-31. What does the abbreviation ANT mean?

Q7-32. What should you do to avoid electrical shock in your radio shack?

Q7-33. How do you make a frequency check on your transmission equipment?

Q7-34. Calculate the voltage across a 1000-ohm resistor that has 1 milliampere flowing through it.

Q7-35. What does the abbreviation rf stand for?

Q7-36. What is a 5-K resistor?

Q7-37. What is a capacitor?

Q7-38. Calculate the power dissipated in the resistor in Question 34.

Q7-39. What is a FET?

Q7-40. What is a microhenry?

Answers to Sample Test No. 2

A7-21. *The maximum penalty is $500.00 per day per offense.*

A7-22. *No.*

A7-23. *250 watts to the final amplifier.*

A7-24. *The Novice can use 21.100–21.200 MHz.*

A7-25. *No music is allowed on the amateur bands.*

A7-26. *The speed of light of radio waves is equal to the frequency of the wave times its wavelength.*

A7-27. *The second harmonic of 7.1 is 14.2 Megahertz.*

A7-28. About 3.750 MHz.

A7-29. *No, this is a general class band.*

A7-30. *It means please send your code slower, or slow up a little.*

A7-31. *ANT is a short form for antenna.*

A7-32. *Ground your equipment to your cold water pipe or electrical ground.*

A7-33. *First align your receiver to WWV or some other standard and then align your transmitter to the receiver.*

A7-34. *The answer is 1 volt. 1 = 1,000 times 0.001.*

A7-35. *The letters rf stand for radio frequency.*

A7-36. *A 5,000-ohm resistor.*

A7-37. *A capacitor is an electrical device that can store energy.*

A7-38. *The answer is 1 milliwatt or 0.001 × 0.001 × 1,000 = 0.001.*

A7-39. *A FET is a field-effect transistor.*

A7-40. *A microhenry is one millionth of a henry which is the measure of inductance of a coil.*

appendix

Morse Code Learning Aid

The following pages contain the letters of the alphabet and numbers 0 through 9 on one side of the page. The equivalent Morse code symbol appears on the reverse side. Each letter or number can be cut out and used as an aid for learning the code.

A	B	C
D	E	F

dah-di-dah-dit

dah-di-di-dit

di-dah

di-di-dah-dit

dit

dah-di-dit

G	H	I
J	K	L

di-dit

di-di-di-dit

dah-dah-dit

di-dah-di-dit

dah-di-dah

di-dah-dah-dah

M	N	O
P	Q	R

dah-dah-dah

dah-dit

dah-dah

di-dah-dit

dah- dah-di-dah

di-dah-dah-dit

S	T	U
V	W	X

di-di-dah

dah

di-di-dit

dah-di-di-dah

di-dah-dah

di-di-di-dah

Y	**Z**	**0**
1	**2**	**3**

dah-dah-dah-dah-dah

dah-dah-di-dit

dah-di-dah-dah

di-di-di-dah-dah

di-di-dah-dah-dah

di-dah-dah-dah-dah

4	5	6
7	8	9

dah-di-di-di-dit

di-di-di-di-dit

di-di-di-di-dah

dah-dah-dah-dah-dit

dah-dah-dah-di-dit

dah-dah-di-di-dit

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Novice Class Amateur Radio License Manual

If you are interested in learning about Amateur Radio, the fascinating hobby that has attracted thousands of ham enthusiasts, and wish to know how to prepare for the all-important Novice Class Amateur Radio License you will find this manual a useful and informative guide.

Maybe you have the interest in Amateur Radio but are afraid because a radio operator must be licensed and is governed closely by FCC rules. You may also fear that it is beyond your ability to pass a licensing examination. Rest assured, you do not have to be either a radio engineer or electronic technician to learn some basic knowledge about radio and what makes it work. And learning Morse code can be great fun and interesting, too.

This manual will dispel these fears by explaining in simple layman's language the knowledge you should have to obtain your Novice Amateur Radio License. You will be introduced to the information on which the examination for the Novice Class license is based.

Questions of the kind used by the FCC on the examinations are included throughout the book. And the answers, with detailed explanations where needed, are also provided.

The structure of Morse code, how to learn it, step-by-step instructions on how you can build your own code practice oscillator, along with operating procedures are covered. Radio theory, direct and alternating current, and Ohm's law are explained. The FCC rules which govern Amateur Radio are also presented. The last chapter contains two sets of sample questions and answers similar to those you will have on your Novice examination. The Appendix includes a complete set of alphabet and number cards which you may cut out and use to learn Morse code.

Novice Class Amateur Radio License Manual is a one-volume source of information required to pass the Novice class examination. You know you can do it.

Phil Anderson is President of Kantronics, Inc., a manufacturer of amateur radio equipment. His first amateur radio license (Novice Class License KN0HSB) was obtained while in junior high school over 20 years ago. He earned an Electrical Engineering degree from the University of Kansas. Phil presently holds an Extra-Class Amateur Radio License W0XI. He is the author of several science fiction articles related to radio and is interested in QRP low-power communications (primarily CW operation) and microprocessors as they apply to amateur radio.

Howard W. Sams & Co., Inc.
4300 WEST 62ND ST. INDIANAPOLIS, INDIANA 46268 USA

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